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Klippel-Trenaunay syndrome and chiari I malformation. A case report and systematic review of the literature

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ABSTRACT

Introduction: Klippel-Trenaunay Syndrome (KTS) is a rare congenital condition characterized by vascular malformations, bone abnormalities, and limb overgrowth. The genetic basis of KTS is not fully understood, and the diagnosis relies on clinical features. Its clinical spectrum includes several neurosurgical diagnoses, such as cavernous hemangiomas, arteriovenous fistulas, and Chiari I malformation.

Research question: This study investigates the neurological complications associated with KTS, focusing on its coexistence with Chiari I malformation and other neurosurgical entities, through a systematic review and a case report.

Methods materials: A 27-year-old woman with KTS and Chiari I malformation presented with progressive tetraparesis and cranial nerve deficits. Emergency foramen magnum decompression had to be undertaken despite significant coagulation abnormalities. Despite her post-operative period being complicated by splenic rupture requiring splenectomy, she demonstrated gradual neurological recovery.

Results: The patient presented with a significant neurological improvement at her 3-month follow-up, being able to walk independently with a stick. A systematic review of the Pubmed database identified 55 patients with KTS requiring neurosurgical attention. The most common pathology was vascular malformations, followed by CNS tumors, whereas Chiari malformation was rare.

Conclusion: The study highlights the challenges of managing patients with KTS and Chiari I malformation, emphasizing the importance of early diagnosis, through preoperative evaluation and interdisciplinary care. Emergency surgery in KTS patients with neurological deterioration, though high risk, can improve outcomes with careful coordination among neurosurgeons, hematologists, and internists. The rare association of Chiari I malformation with KTS underscores the need for vigilance and a tailored approach to care.

1. Introduction

Klippel-Trenaunay syndrome (KTS) is a rare congenital syndrome first described in 1900, with an estimated prevalence of 1–5 in 100,000 cases worldwide and no gender, racial or hereditary pattern (Lacerda et al., 2014; Oduber et al., 2008; Zhai et al., 2019). The syndrome is characterized by abnormal blood vessels, bones and soft tissue development. The Hamburg classification of vascular malformation classifies KTS as a mixed vascular abnormality consisting of capillary, lymphatic and venous malformations (Belov, 1993; Lee et al., 2007). However, in the most recent classification of the International Society for the Study of Vascular Anomalies (ISSVA) in 2018, KTS is defined as a syndrome with capillary and venous malformations and limb overgrowth, with or without lymphatic malformation (Kunimoto et al., 2022). Moreover, it includes KTS in a group of disorders within the PIK3CA-related overgrowth spectrum (PROS). The diagnosis relies on the classical triad of port-wine stain birthmarks, venous malformations, and tissue/bone abnormalities. The syndrome may also present with vascular malformations, hydrocephalus or cerebral calcification (Cristaldi et al., 1995; Torregrosa et al., 2000; Williams and Elster, 1992). KTS should not be confused with Parks-Weber syndrome (PWS), a similar syndrome but with high-flow arteriovenous malformations. Chiari I malformation (CIM) is defined by the herniation of the cerebellar tonsils through the foramen magnum, often leading to compression of the brainstem and

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spinal cord. CIM is associated with various neurological symptoms, including headache, cranial nerve deficits and syringomyelia. While Chiari malformation has been classified into subtypes (I-IV) (Elton et al., 2002; Snee et al., 2021), this study focuses exclusively on Chiari I malformation, the subtype relevant to this case. The coexistence of KTS and CIM is exceedingly rare and overlapping clinical features complicate diagnosis and management. These conditions may exacerbate neurological deterioration, often necessitating urgent surgical intervention. This study explores the neurosurgical implications of KTS, highlights the challenges in managing coexisting CIM, and provide a comprehensive review of the literature on KTS with neurosurgical involvement.

2. Methods

We have screened the PubMed library for any association of the syndrome with pathologies addressed by neurosurgery. An advanced search was performed in two stages; the first search screened for any signs of the syndrome in the brain and spine, and the second search screened for studies reporting both Chiari malformation and KTS. The advanced search terms were ((brain) OR (spine)) AND (klippel trenaunay), and for the second search was (chiari) AND (klippel trenaunay). Moreover, the references from the included studies were also screened for other publications about the co-existence of Chiari and KTS. Original studies and case reports were included in the analysis without any discrimination for the population and with no time filter. Articles written in English, French, and German language were included. Exclusion criteria applied to reviews, simple abstracts, letters to the editors, or any other publication without patient cases. Finally, we present our rare case of an adult patient with KTS, Chiari type I malformation and intramedullary hemorrhage. A written consent for the case report and the images was received from the patient.

3. Results

3.1. Case presentation

A 27-year-old lady presented due to progressive paresis in the last week before admission to the emergency department. Her paresis

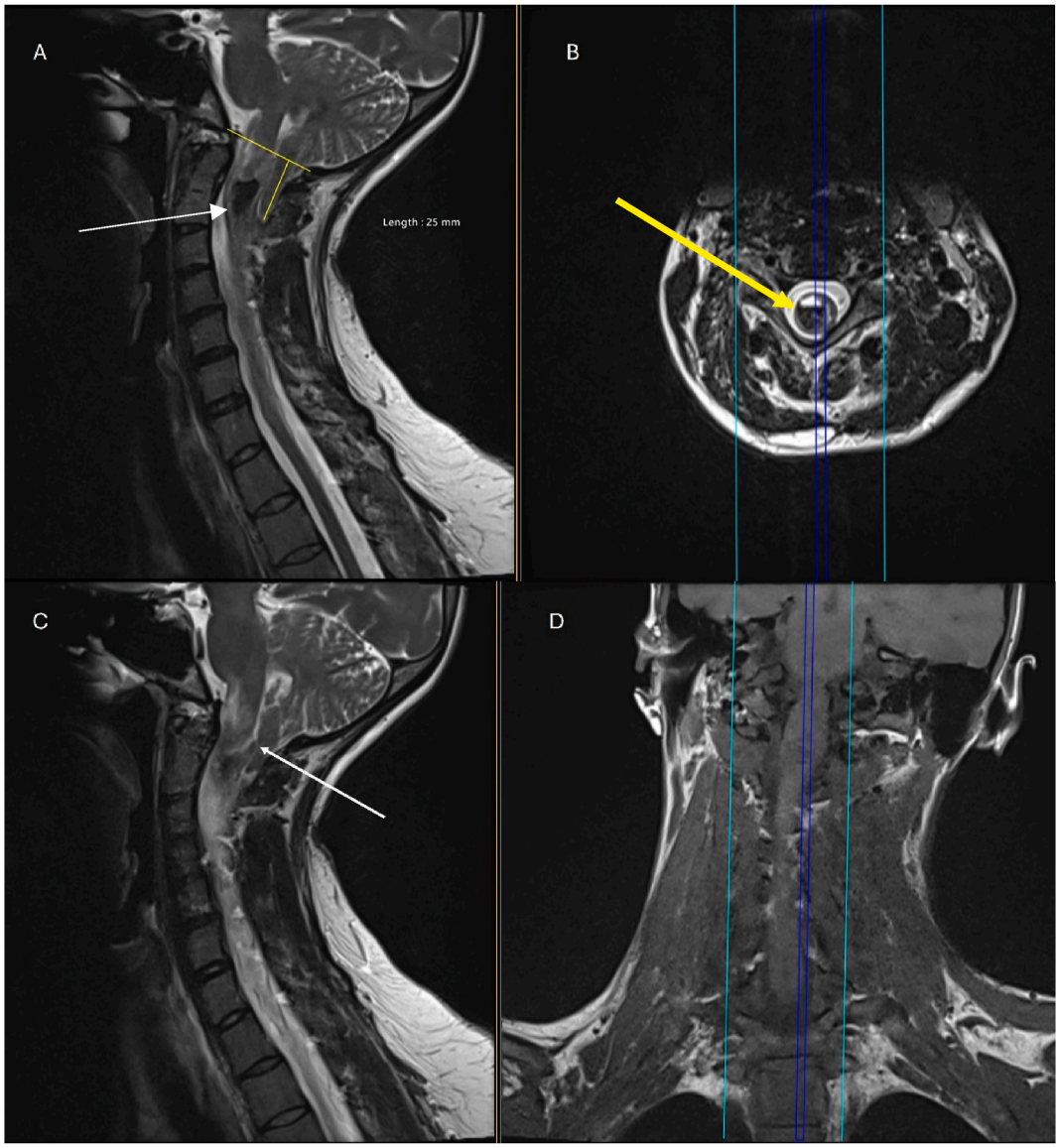

Fig. 1. Pre-operative craniocervical and spine MRI. A. Sagittal view of T2WI sequence. Tonsillar ectopia measured at 25mm. White arrow shows syrinx within the spinal cord, with mixed signal, low intensity cephalic, isointense caudally B. Axial view of T2WI sequence at the level of the superior endplate of C4. Yellow arrow shows the fluid level in the syrinx. C. Sagittal view of T2WI sequence. White arrow shows the obex of the cerebellum. D. Respective coronal view for localization.

started from her right arm, followed by her right and left legs. At presentation she was bound in a wheelchair, with cranial nerve deficits (IX, X, XI) and muscle strength graded at 2/5 in the affected limbs. Cerebellar and sensory examination were normal. Radiological investigations included CT of the brain, cervical spine, thorax and abdomen, Digital Subtraction Angiography (DSA) and MRI scan of the neuraxis (Fig. 1) and abdomen. Preoperative MRI done prior to her neurological deterioration revealed Chiari I malformation, with tonsillar ectopia extending to C2, a syrinx from C1 to C7, and acute intramedullary hemorrhage at C2 with hemosiderin deposition from the obex to C6. These findings suggested a vascular event, possibly adjacent to the syrinx, as the cause of her rapid neurological decline. Preoperative imaging raised suspicion for a cavernoma, but no definitive vascular anomaly was identified. Abdominal imaging revealed hepatomegaly and splenomegaly but no vascular abnormalities. The patient's past medical history included hypothyroidism and iron deficiency anemia. During her hospital stay, the case was managed by a multi-disciplinary team (MDT) under the care of neurosurgery, with physicians, haematologists, neurologists and neuroradiologists. Her physical examination revealed hepatomegaly, splenomegaly, and soft tissue hypertrophy of both lower limbs, presenting syndactyly, lymphoedema and capillary hemangiomas (port-wine stains) (Fig. 2). Her blood tests suggested disseminated intravascular coagulation or consumptive coagulopathy, with negative immunological viral panels. The medical department was in charge of optimizing the patient for surgery. However, her neurological status rapidly deteriorated to tetraplegia with deficits from lower cranial nerves (i.e. dysphagia) and without any improvement of her haematological profile. The consensus of the MDT was to proceed with emergency foramen magnum decompression and C1-C3 laminectomy to address the Chiari malformation and clot evacuation if possible. The patient and her family were informed about the outcome of the MDT, and she was also informed in detail about the benefits and risks for an operation. They provided a written consent, and she underwent a typical Chiari decompression with foramen magnum decompression and C1-3 laminectomy aiming to evacuate the clot. However, due to medium but continuous bleeding, the clot was not followed. A duroplasty was completed using synthetic dura, with a running suture and fibrin glue to minimize cerebrospinal fluid (CSF) leakage. During the operation, the patient received enormous amounts of plasma, fibrinogen, tranexamic acid, and blood transfusion, and even so, the rotational thromboelastography (ROTEM) was suggestive of reduced clot firmness. Her immediate post-operative period was uneventful, and the patient recovered her muscle strength to 2/5. Her late postoperative period was complicated by abdominal pain, which was the aftermath of spleen microrupture. Eventually, she underwent a splenectomy, improving both her clinical status and coagulation profile. At her 3-month follow-up, the patient is in a rehabilitation centre, and she has regained her strength in her left upper limb at 5/5, her right upper limb at 4-/5, her left lower limb at 5/5, and her right lower limb at 3/5. She has no deficits from lower cranial nerves, and she has recovered well from her abdominal surgery. Her follow-up MRI was satisfactory, demonstrating resorption of the hemorrhage and reduction in the size of the syrinx, with hemosiderin deposition extending from the obex to C6 (Fig. 3). A pseudomeningocele was noted but did not contribute to spinal cord compression. The finding and the options were discussed with the patient and the family, and since she was improving, both the surgical team and the patient did not opt for a surgical intervention. Contrast enhancement at the C3-4 level was identified, raising questions about the etiology of the lesion, with cavernoma being the most likely diagnosis.

3.2. Systematic review results

This systematic review was conducted following the PRISMA guidelines to ensure a rigorous and structured approach to identifying and analyzing relevant studies. The advanced search terms were developed to focus on the association of Klippel-Trenaunay Syndrome (KTS) with neurosurgical pathologies, using PubMed as the primary database. PubMed was chosen due to its comprehensive indexing of high-quality, peer-reviewed medical and neurosurgical literature, which aligns with the scope of this review. The search yielded 142 studies, of which 8 were duplicates and thus removed. Subsequently, 134 articles

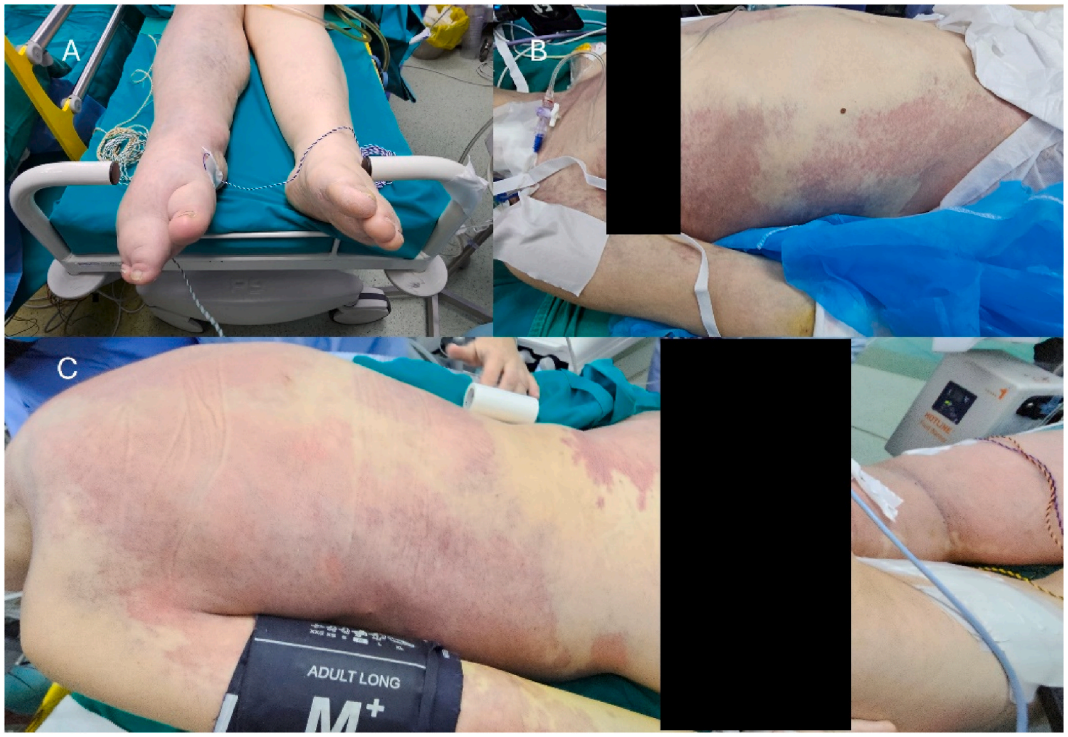

Fig. 2. Patient in the operating theatre. A. Lower limbs deformity with syndactyly and lymphedema. B and C. Port-wine stains of the torso and back, respectively.

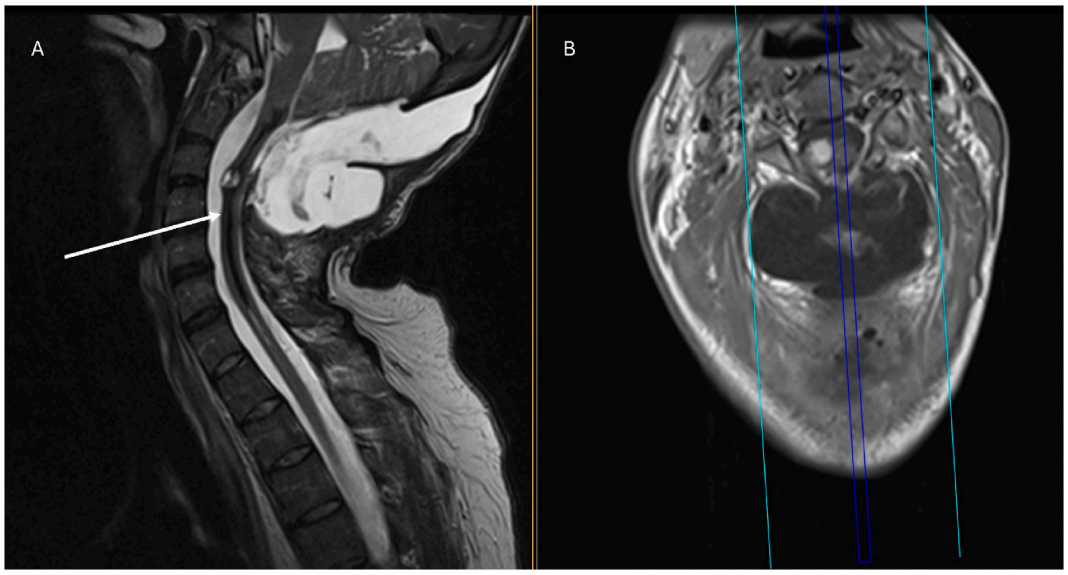

Fig. 3. Post-operative MRI. A. Sagittal view of MRI T2WI sequence. White arrow shows the syrinx. B. Axial view of MRI T1WI with contrast, at the level of inferior endplate of C3. The post-op MRI also shows a large pseudomeningocele without compression of the spinal cord.

were screened based on title and abstract, following the exclusion criteria set previously by two independent authors. A third independent author resolved any discrepancies. This process resulted in 87 excluded studies and 47 reports for full-text review and assessed for eligibility. Finally, thirty-two reports were included in our study (Fig. 4). These reports discuss a total of 55 patients with KTS and clinical signs needing neurosurgical attention. The distribution of patients in studies is not homogenous, and the majority of the patients (N = 17) come from the analysis of Covington et al. (2021). The mean age of the pooled population is 33.67, ranging from 1.5 to 74 years and a male-to-female ratio of 1:1.15 (25 men and 30 women). Vascular malformations are the most common neurosurgical entity coexisting with KTS, consisting of venous anomalies, cavernous hemangiomas, aneurysms, arteriovenous malformations and fistulas of the brain and spine (Fig. 5) (Boutarbouch et al.,

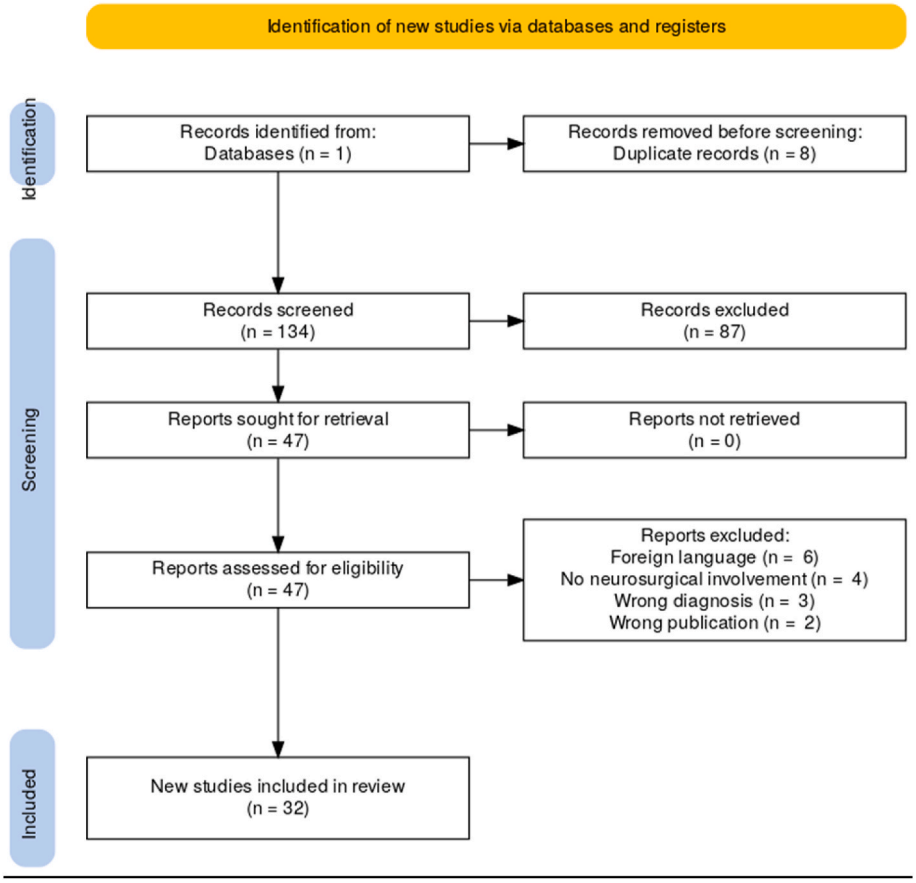

Fig. 4. PRISMA flow-chart

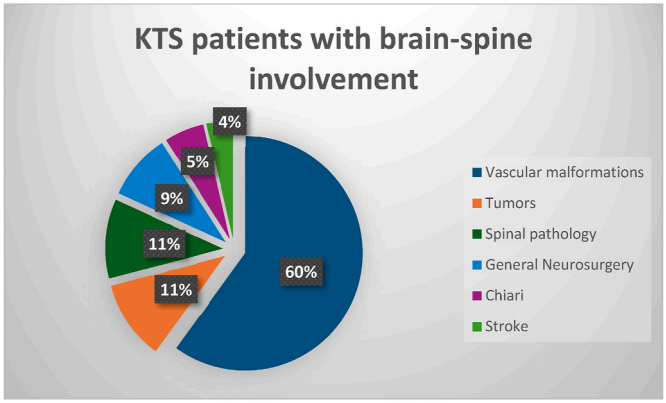

Fig. 5. KTS patients (%) in grouped neurosurgical entities

2010; Dunn and Jaspan, 1993; Goksu et al., 2012; Hallan et al., 2020; Ishimoto et al., 2002; Jaksch et al., 1986; Karadag et al., 2019; Oda et al., 2018; Perez-Alfayate et al., 2020; Pichierri et al., 2006; Ricks et al., 2014; Rohany et al., 2007; Star et al., 2010; Sudmeyer et al., 2011; Yoshinaga et al., 2018). Other pathologies included scoliosis (Zhai et al., 2019; Arai et al., 2002), stroke (Sakai et al., 2011; Beume et al., 2013), primary nervous system tumors (Blatt et al., 2019; Bothun et al., 2011; Choi et al., 2011; Howitz et al., 1979; Yilmaz et al., 2015), hydrocephalus (Gupte et al., 1995), Chiari type I malformation (Snee et al., 2021; Sangeetha et al., 2019), and spontaneous intracranial hypotension (Madhavan et al., 2020) (Table 1). A summary of the articles included in the study is presented in appendix.

4. Discussion

Klippel-Trenaunay syndrome (KTS) is a rare congenital disorder characterized by vascular malformations, bone deformities, and port-wine stain birthmarks. These features typically affect the lower limbs but may involve the trunk and upper limbs. Additional symptoms include seizures, coagulopathies, anemia, lymphedema, various organ abnormalities, cataracts or glaucoma, abnormal fatty deposits, and hip/pelvic asymmetry or hip dislocation. The syndrome can also rarely exhibit seizures, blood abnormalities such as disseminated or localized intravascular coagulopathy, blood clots or anemia, rectal or vaginal bleeding, lymphedema syndactyly, acrodactyly, polydactyly, metatarsal, and phalangeal agenesis to osteolysis, as well as cardiovascular, gastrointestinal, liver, spleen and genitourinary tract problems. KTS syndrome should not be confused with Parks-Weber syndrome (PWS), which involves high-flow arteriovenous malformations (Chagas et al., 2017). While the two conditions are sometimes used interchangeably the ISSVA classification defined them as distinct entities in 2018. Our systematic review identified 56 patients suffering from KTS and

Table 1
Number of KTS patients with neurosurgical pathologies.

Pathologies	Number of patients (%)
Venous anomalies	15 (27.27%)
Arteriovenous fistulas	3 (5.45%)
Arteriovenous malformations	2 (3.63%)
Aneurysms	1 (1.81%)
Cavernous hemangiomas	12 (21.81%)
Brain tumors	6 (10.91%)
Stroke	2 (3.63%)
Chiari	3 (including the present case), (5.45%)
Hydrocephalus	1 (1.81%)
Spinal lipoma	1 (1.81%)
Spinal meningeal cyst	1 (1.81%)
Scoliosis	2 (3.63%)
Intraosseous hemangioma	2 (3.63%)
Spontaneous intracranial hypotension	4 (7.27%)

neurosurgical pathologies, including the present case. Vascular malformations were the most common (60%), followed by central nervous system (CNS) tumors of the patients (10.9%) and other neurosurgical conditions (29.1%). CNS tumors came from case reports of the co-existence of the syndrome with glioblastoma, pituitary adenoma, prolactinoma, astrocytoma, ganglioglioma and optic glioma. Chiari malformation was found only in 5.45% (n = 3 cases), while spine pathologies were found in 27.27% of the patients with KTS. The genetics basis of KTS remains partially understood, with proposed mechanisms including overexpression of the angiogenic factor VG5Q (Tian et al., 2004), a de novo supernumerary ring chromosome 18 (Harnarayan and Harnanan, 2022; Jacob et al., 1998; Timur et al., 2004), or the PIK3CA-related overgrowth spectrum (PROS) mutation of the *PIK3CA* gene (Kunimoto et al., 2022; Mirzaa et al., 1993; Castillo et al., 2019; Vahidnezhad et al., 2016). The latter has been implicated in the development of venous and lymphatic vascular malformations (Castillo et al., 2019). These mutations are somatic and not inherited, affecting specific tissues and contributing to venous and lymphatic malformations. Different tissues may be involved individually or in combination, such as bones, muscle, fat, nerves, brain and blood vessels. Germline mutations in RASA1 are not found in KTS patients (Revencu et al., 2013).

The coexistence of KTS and Chiari malformation is exceedingly rare. To our knowledge, this is the first case of an adult patient with KTS and a CIM presenting with a spontaneous intramedullary hemorrhage. The preoperative MRI, performed prior to the patient's progression to tetraplegia, confirmed an intramedullary hemorrhage at C2 and hemosiderin deposition extending from the obex to C6, likely causing the patient's rapid neurological decline. These findings strongly suggest that the rapid neurological decline was due to hemorrhage, likely originating from a vascular anomaly such as a cavernoma, rather than CIM or syringomyelia alone.

The 2-month postoperative MRI revealed a lesion at C3-4 with atypical contrast enhancement, raising alternative diagnoses such as angioblastoma. However, a cavernoma remains the most plausible explanation given the hemosiderin deposition, despite the absence of definitive findings on susceptibility-weighted imaging (SWI) or digital subtraction angiography (DSA). The vascular complication added a new dimension to the clinical complexity of managing KTS and CIM.

The patient's rapid neurological deterioration necessitated urgent decompression. Surgical management was complicated by coagulopathy, hepatomegaly, and splenomegaly, increasing the risk of intraoperative hemorrhage, but neural decompression was prioritized. The operation was medically and surgically challenging, as risks lay in every step. Positioning of the patient had to be done with care due to the combination of her hepato/splenomegaly and her haematological disorders. Decompression of Chiari with C1 laminectomy was also challenging in terms of blood loss. Hemostasis was done under surveillance using thromboelastography (ROTEM), yet it proved difficult, while medullotomy for clot evacuation was avoided to minimize risks. Her overall postoperative period was not uneventful, and during her hospital stay, her clinical and haematological status worsened, leading the patient to undergo a splenectomy due to spleen microrupture. However, at her 3-month follow-up, the patient's neurological status had significantly improved, with satisfactory imaging showing resorption of the hemorrhage and reduction of the syrinx size. Similar to previously reported cases (Snee et al., 2021; Sangeetha et al., 2019), our patient presented with neurological symptoms attributed to Chiari malformation, necessitating surgical intervention. All cases required careful evaluation of vascular anomalies, highlighting the importance of detailed preoperative imaging. On the other hand, our case is a fully grown woman, who presented with a spontaneous intramedullary hemorrhage, likely related to an underlying cavernoma. This vascular anomaly added a new dimension to the clinical complexity of KTS and Chiari malformation co-occurrence. Moreover, the significant hematological complications, including coagulopathy and subsequent splenectomy, added another degree of difficulty in managing the case,

distinguishing it as particularly challenging.

5. Limitations

Due to scarce studies on Klippel Trenaunay syndrome, one cannot make safe assumptions about its natural course when or if it is complicated with a neurosurgical entity. Furthermore, some studies report multiple lesions on patients without referring to the exact number of them or the number of patients who have multiple lesions. The data presented herein come mainly from case reports, and only one study included a larger number of patients. Limiting the database search to PubMed may also be a potential limitation. While PubMed provides extensive coverage, including additional databases such as Scopus, Web of Science, or Embase in future research could enhance the comprehensiveness of the review. The choice of PubMed was driven by its direct relevance to the study focus and its indexing of case reports and original research pertinent to neurosurgical complications. Given the rarity of KTS and its overlap with neurosurgical pathologies, the scarcity of available literature might mean that expanding the search to other databases would have a minimal impact on the number of included studies. Nevertheless, incorporating other databases in future reviews could provide additional insights into this rare association.

6. Conclusion

Chiari malformation is a much more common diagnosis than KTS, but the presence of a Chiari malformation can complicate the case even more and contribute to a patient's morbidity. Pediatricians and neurosurgeons should be aware of this possible scenario, as a Chiari malformation might result in neurological deterioration. These patients are probably best followed up in a joint clinic with pediatric neurosurgeons. At the pediatric-to-adult population handover, neurosurgeons should always be added to the team of physicians and haematologists. Even though a combination of a Chiari malformation and a KTS is quite rare, these patients may benefit from a decompression, but under strict interdisciplinary care coordination. Hematological disorders increase the risk of surgical complications, but rapid neurological deterioration is a red flag to be taken into consideration that warrants a high-risk operation.

Disclosures

The authors report no conflict of interest.

Author Contributions

Conception and design: D. Giakoumettis, K. Vlachos, B. Acquisition of data: D. Giakoumettis, T. Vogiatzoglou, G. Vavoulis, B. Almasarwah, K. Tilidou. Analysis and interpretation of data: D. Giakoumettis, K. Vlachos, Drafting the article: D. Giakoumettis, A. Tsitlakidis. Critically revising the article: D. Giakoumettis, A. Tsitlakidis, K. Vlachos. Reviewed submitted version of the manuscript: D. Giakoumettis, A. Tsitlakidis, K. Vlachos. Approved final version of the manuscript on behalf of all authors: D. Giakoumettis, T. Vogiatzoglou, G. Vavoulis, B. Almasarwah, K. Tilidou, A. Tsitlakidis, K. Vlachos. Administrative/technical/material support: D. Giakoumettis, K. Vlachos. Study supervision: K. Vlachos.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix

title	authors	doi	N	Year	Journal	Location	Pathology other than KTS	Study Design
Intracranial and extracranial vascular manifestations of patients with a clinical diagnosis of Klippel-Trenaunay syndrome	Covington TN, Anderson KR, Tollefson MM, Guerin JB, Brinjikji W.	10.1007/s00234-020-02560-3	50	2020	Pediatric Neuroradiology	USA	1) Developmental Venous Anomaly, 2) Craniofacial venous malformation, 3) intracranial/ extracranial venous anomaly, 4) venous sinus developmental abnormality, 5) intraosseous venous malformation, 6) cavernous malformation	Retrospective cohort
Dilated Epidural Venous Plexus Causing Radiculopathy: A Report of 2 Cases and Review of the Literature	Hallan DR, McNutt S, Reiter GT, Thamburaj K, Specht CS, Knaub M.	10.1016/j.wneu.2020.09.036	1	2020	World Neurosurgery	USA	Dilated Epidural Venous Plexus Causing Radiculopathy	Case report
Klippel-Trenaunay-Weber Syndrome Associated with Multiple Cerebral Arteriovenous Malformations: Usefulness of Gamma Knife Stereotactic Radiosurgery in This Syndrome	Pérez-Alfayate R, Martínez-Moreno N, Rosati SD, Moreu-Gamazo M, Pérez-García C, Martínez-Alvarez R.	10.1016/j.wneu.2020.06.012	1	2020	World Neurosurgery	Spain	Cerebral arteriovenous malformation	Case report
Association Between Klippel-Trenaunay Syndrome and	Madhavan AA, Kim DK, Carr CM, Luetmer PH, Covington TN,	10.1016/j.wneu.2020.03.148	4	2020	World Neurosurgery	USA	Spontaneous Intracranial Hypotension	Case report

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title	authors	doi	N	Year	Journal	Location	Pathology other than KTS	Study Design
Spontaneous Intracranial Hypotension: A Report of 4 Patients	Cutsforth-Gregory JK, Brinjikji W.							
Cancer Risk in Klippel-Trenaunay Syndrome	Blatt J, Finger M, Price V, Crary SE, Pandya A, Adams DM.	10.1089/lrb.2018.0049	24	2019	Lymphatic Research and Biology	USA	1) Ganglioglioma, 2) prolactinoma, 3) pituitary adenoma, 4)	Retrospective cohort
Klippel-Trenaunay-Weber Syndrome with Atypical Presentation of Cerebral Cavernous Angioma: A Case Report and Literature Review	Karadag A, Senoglu M, Sayhan S, Okromelidze L, Middlebrooks EH.	10.1016/j.wneu.2019.03.132	1	2019	World Neurosurgery	Turkey	Cerebral cavernous angioma	Case report
Cerebral and spinal cavernomas associated with Klippel-Trenaunay syndrome: case report and literature review	Yoshinaga T, Yagi K, Morishita T, Abe H, Nonaka M, Inoue T.	10.1007/s00701-017-3408-5	1	2017	Acta neurochirurgica (Wien)	Japan	Brain and spine cavernous angiomas	Case report
Spinal Cavernous Angioma Associated with Klippel-Trenaunay-Weber Syndrome: Case Report and Literature Review	Oda K, Morimoto D, Kim K, Yui K, Kitamura T, Morita A.	10.1016/j.wneu.2017.10.040	1	2017	World Neurosurgery	Japan	Spinal cord cavernous angioma	Case report
Glioblastoma multiforme in Klippel-Trenaunay-Weber syndrome: a case report	Yilmaz T, Cikla U, Kirst A, Baskaya MK.	10.1186/s13256-015-0555-2	1	2015	Journal of Medical Case Reports	USA	Glioblastoma multiforme	Case report
Klippel-Trenaunay syndrome and cavernous malformations	Ricks CB, Grandhi R, Ducruet AF.	10.1136/bcr-2014-207486	1	2014	BMJ Case Reports	USA	Cavernous angioma	Case report
Coincidence of ischemic stroke and recurrent brain hemorrhage in a patient with Klippel-Trenaunay Syndrome	Beume LA, Fuhrmann SC, Reinhard M, Harloff A.	10.1016/j.jocn.2012.10.039	1	2013	Journal of Clinical Neuroscience	Germany	1) Ischemic stroke, 2) cerebellar hemorrhage	Case report
Multiple spinal cavernous malformations in Klippel-Trenaunay-Weber syndrome	Göksu E, Alpsoy E, Uçar T, Tuncer R.	10.5114/ninp.2012.31362	1	2012	Neurologia i Neurochirurgia polska	Turkey	Multiple cavernous malformations	Case report
Spinal extradural meningeal cyst in klippel-trenaunay syndrome	Choi KC, Ahn ST, Shin YH, Lee SH.	10.3340/jkns.2011.49.5.299	1	2011	Journal of Korean Neurosurgical Society	Korea	Spinal extradural meningeal cyst	Case report
Bilateral optic nerve drusen and gliomas in Klippel-Trenaunay syndrome	Bothun ED, Kao T, Guo Y, Christiansen SP.	10.1016/j.jaapos.2010.10.009	1	2011	Journal of AAPOS	USA	Optic nerve and chiasmal gliomas	Case report
Paradoxical brain embolism with Klippel-Trenaunay syndrome	Sakai K, Sibazaki K, Kimura K, Kobayashi K, Matsumoto N, Iguchi Y.	10.2169/internalmedicine.50.3870	1	2011	Internal Medicine	Japan	Paradoxical Brain Embolism	Case report
Action tremor caused by olivary cavernoma in Klippel-TrÃ©naunay syndrome mimicking asymmetric essential tremor	Südmeyer M, Maroof P, Saleh A, Hartmann C, Wojtecki L, Schnitzler A.	10.1007/s00415-010-5675-4	1	2010	Journal of Neurology	Germany	Olivary cavernoma causing action tremor	Case report
Multiple cerebral and spinal cord cavernomas in Klippel-Trenaunay-Weber syndrome	Boutarbouch M, Ben Salem D, Giré L, Giroud M, Béjot Y, Ricolfi F.	10.1016/j.jocn.2009.11.013	1	2010	Journal of Clinical Neuroscience	France	Multiple brain and spine cavernous malformations	Case report
Intracranial aneurysms in klippel-trenaunay/weber syndromes: case report	Star A, Fuller CE, Landas SK.	10.1227/01.NEU.0000368392.69904.BE	1	2010	Neurosurgery	USA	Intracranial aneurysms	Case report
Giant multilevel thoracic hemangioma	Grau SJ, Holtmannspoetter M,	10.1097/BRS.0b013e3181a4e4b8	1	2009	Spine (Phila Pa, 1976)	Germany	Giant Multilevel Thoracic Hemangioma	Case report

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title	authors	doi	N	Year	Journal	Location	Pathology other than KTS	Study Design
with spinal cord compression in a patient with Klippel-Weber-Trenaunay syndrome: case report	Seelos K, Tonn JC, Siefert A.							
Spinal arteriovenous malformations associated with Klippel-Trenaunay-Weber syndrome: a literature search and report of two cases	Rohany M, Shaibani A, Arafat O, Walker MT, Russell EJ, Batjer HH, Getch CC.	PMID: 17353342	2	2007	AJNR American Journal of Neuroradiology	USA	Spinal arteriovenous fistula	Case report
Klippel-Trenaunay-Weber syndrome and intramedullary cervical cavernoma: a very rare association. Case report	Pichierri A, Piccirilli M, Passacantilli E, Frati A, Santoro A.	10.1016/j.surneu.2005.11.062	1	2005	Surgical Neurology	Italy	Intramedullary cervical cavernoma	Case report
Spinal cord compression caused by an extradural lipoma in Klippel-Trenaunay-Weber syndrome. Case illustration	Ashkan K, Moore AJ.	10.3171/spi.2002.February 97, 0269	1	2002	Journal of Neurosurgery	UK	Spinal extradural lipoma	Case illustration
Sensorineural hearing loss with intracranial venous malformations in Klippel-Trenaunay syndrome	Ishimoto S, Ito K, Matsuzaki M, Kimura M.	10.1177/000348940211100613	1	2002	The Annals of Otology Rhinology Laryngology	Japan	Intracranial venous malformation	Case report
Myelopathy due to scoliosis with vertebral hypertrophy in Klippel-Trenaunay-Weber syndrome	Arai Y, Takagi T, Matsuda T, Kurosawa H.	10.1007.s004020100334	1	2002	Archives of Orthopaedic and Trauma Surgery	Japan	Myelopathy due to scoliosis	Case report
Klippel-Trenaunay-Weber syndrome with hydrocephalus: an unusual association	Gupte GL, Deshmukh CT, Bharucha BA, Irani SF.	10.1159/000120924	1	1995	Pediatric Neurosurgery	India	Hydrocephalus	Case report
Case report: cerebral arteriovenous fistula in the Klippel-Trenaunay-Weber syndrome	Dunn WK, Jaspan T.	10.1016/s0009-9260(05)81089-x	1	1993	Clinical Radiology	UK	Cerebral arteriovenous fistula	Case report
Cerebral hemorrhage in arteriovenous malformation associated with Klippel-Trenaunay syndrome	Jaksch H, Bewermeyer H, Dreesbach HA, Heiss WD.	10.1007/BF00313992	1	1986	Journal of Neurology	Germany	Cerebral arteriovenous malformation	Case report
A variant of the Klippel-Trenaunay-Weber syndrome with temporal lobe astrocytoma	Howitz P, Howitz J, Gjerris F.	10.1111/j.1651–2227.1979.tb04971.x	1	1979	Acta Paediatrica Scandinavica	Denmark	Temporal lobe astrocytoma	Case report
Vertebral and epidural hemangioma with paraplegia in Klippel-Trenaunay-Weber syndrome. Case report	Gourie-Devi M, Prakash B.	10.3171/jns.1978.May 48, 0814	1	1978	Journal of Neurosurgery	India	Vertebral and epidural hemangioma	Case report
Chiari I malformation with Klippel-Trenaunay syndrome: case report and review of the literature	Snee IA, Mazzola CA, Sikorskyj T.	10.1007/s00381-020-04992-x	1	2021	Child's Nervous System	USA	Chiari 1	Case report
Craniotomy in Klippel-Trenaunay syndrome: Concerns and challenges	Sangeetha RP, Baskar N, Kamath S, Dixit P.	10.4103/ija.IJA_510_19	1	2019	Indian Journal of Anaesthesia	India	Chiari 1	Case report
Kyphoscoliosis with Klippel-Trenaunay syndrome: a case report and literature review	Zhai J, Zhong ME, Shen J, Tan H, Li Z.	10.1186/s12891-018-2393-z	1	2019	BMC Musculoskeletal Disorders	China	Kyphoscoliosis	Case report

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